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ABSTRACT

Spearman's formulation of analogical reasoning as a three-stage process (apprehension of elements, education of relations, and education of correlates) appears to be useful in the study of analogical reasoning. In this project, minimizing the role of element apprehension and manipulating relation-education levels resulted in the unexpected finding of minimal effects due to social class. It was concluded that the effects of social class differences on analogical reasoning are to be found primarily in the stage of apprehending the elements. Results also led to the hypothesis that the most important stage in analogical reasoning is the education of correlates. An advantage in educing relations that is given to a group exerts only minimal influence on the test performance outcome. The finding of a hierarchical ordering of preference for relations in the solution of analogy problems further clarifies the locus of the effects of social class, specifically, and culture, generally, on analogy test performance. These effects are contingent on the elements and the relations embodied in the analogy test. (Author/LL)

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EFFECTS OF SOCIAL CLASS DIFFERENCES ON ANALOGICAL REASONING

Rene' V. Dawis

FINAL REPORT OF ACTIVITIES THROUGH DECEMBER 31, 1974

Department of Psychology
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February 1975

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Spearman's formulation of analogical reasoning as a three-stage process (apprehension of elements, eduction of relations, and eduction of correlates) appears to be useful in the study of analogical reasoning. In this project, minimizing the role of element apprehension and manipulating relation eduction levels resulted in the unexpected finding of minimal effects due to social class. It is concluded that the effects of social class differences on analogical reasoning are to be found primarily in the stage of apprehending the elements.

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Project findings also led to the hypothesis that the most important stage in analogical reasoning is the eduction of correlates. An advantage in educing relation that is given to a group exerts only minimal influence on the test performance outcome.

The finding of a hierarchical ordering of preference for relations in the solution of analogy problems further clarifies the locus of the effects of social class specifically, and culture, generally, on analogy test performance. These effects are contingent on the elements and the relations embodied in the analogy test.

Effects of Social Class Differences on Analogical Reasoning

Rene' V. Dawis

Oppenheimer (1956) calls analogy the "indispensable and inevitable tool" in the task of scientific discovery and invention. The importance of analogical reasoning as a cognitive ability can be seen in its almost universal use as a test item type in psychometric measures of intelligence or general mental ability (Dawis & Siojo, 1972, Technical Report No. 1). Spearman (1927) considered analogical reasoning as the essence of intelligence.

Yet, for all its apparent importance, little effort has been devoted by psychologists to the study of the analogical reasoning process as contrasted with the psychometric use of analogy test items. The few exceptions to this observation include studies that found the solution of verbal analogy items to depend on word association (Gentile, Gentile, & Kessler, 1969; Goldstein, 1962; Scheerer, Rothman, & Goldstein, 1945; Willner, 1964) and on word knowledge, i.e., vocabulary level (Gentile, 1968; Gentile et al., 1969; Willner, 1964). These findings appear to have some bearing on the consistent report of social class differences in analogy test performance, in favor, of course, of the higher social class (Tyler, 1965).

This project was originated and designed with two objectives in mind: The general objective was to investigate the analogical reasoning process as it is manifested in the solution of analogy test items. The specific objective was to investigate the effects of social class differences on this process.

A survey of the literature (Dawis & Siojo, 1972) convinced the principal investigator of the utility of Spearman's theory (Spearman, 1927) for the purposes of the project. According to Spearman, analogical reasoning proceeds in three stages:

1. The elements are apprehended.
2. The relation binding the elements is "educed."
3. The "correlate" is educed, given the previously educed relation.

Applied to the analogy test item of the form a : b :: c : ?, solution of the item would entail:

1. apprehending (identifying, understanding) elements a, b, and c (e.g., three words in a verbal analogy test item);
2. educing the relation that binds the a : b pair together; and
3. using the educed a : b relation to solve the c : ? pair by educing the appropriate correlate, d, that has the same relation to c as b has to a.

The Spearman formulation suggests that three variables influence the solution of analogy test items:

1. level of difficulty of apprehending the elements;
2. type of relation; and
3. level of difficulty of educing a given relation in a given element pair.

In the case of verbal analogies, the first variable would be a function of vocabulary level or level of difficulty of the words used in the analogies. Because of the well-known differences in vocabulary level (as well as type of vocabulary) between social classes, it was decided to hold this variable constant since it presumably gave the advantage to the higher social class. Additionally, vocabulary level is apparently confounded with analogical reasoning ability in typical psychometric verbal analogy tests, since scores on such tests correlate highly (.70s and .80s) with vocabulary test scores (Dawis & Siojo, 1972). Hence to isolate the analogical reasoning process, it was felt necessary to eliminate or minimize the confounding effects of vocabulary level.

It was also decided to include pictorial analogies in the study. According to Guilford (1967), there are separate factors for analogical reasoning ("cognition of relations") when applied to the different "contents" of "semantic" (verbal) and "figural" (pictorial) material. On the other hand, Tinsley and Dawis (1972) found high equivalence between verbal and picture analogy test items, leading them to conclude that parallel forms of word and picture analogy tests could be constructed. Furthermore, in published research, Ace and Dawis in 1971 found that a verbal analogy test showed the expected difference between higher and lower social class groups, while an equivalent picture analogy test did not.

Method

Development of the Pool of Element Pairs

A list of verbal analogy items was compiled from available psychometric tests. These items were then "decomposed" into word pairs. Pairs were eliminated if they included words not found in the Thorndike-Lorge list of 5,000 most frequently occurring words or in the Dale-Chall fourth grade list. Augmented by staff-written word pairs, a list of 1,000 word pairs was compiled. An additional 500 word pairs were derived from the Russell-Jenkins (1954) word association norms. Five word pairs were constructed for each Kent-Rosanoff stimulus word: one pair with the most frequently occurring response word, one pair with a unique response word, and three pairs with response words of intermediate frequencies of occurrence. All words had to meet the criteria of word difficulty mentioned above.

Line drawings were made of words in the preceding word-pair list that could be drawn. Drawings of common objects and events not found in the word-pair list were added, making a total of 900 pictures. The pictures were submitted to 971 ninth and tenth grade high school students for identification. Only pictures with at least 90% "correct" identification were

retained. The modal word given as identification of the picture was used as its word equivalent. (See Haynes, Dawis, Siojo, & Soriano, 1973, Technical Report No. 2, for more details).

Picture pairs were then constructed to parallel (be equivalent to) the word pairs in the study list. Some picture pairs with no word-pair equivalents (i.e., not in the word-pair list) were constructed, to make a total pool of 500 picture pairs.

Development of the List of Relations

Whitely (1973), in a dissertation conducted under the supervision of the principal investigator, utilized latent partition analysis (Wiley, 1967) to investigate student self-bounded classification of verbal analogy items according to similarity of relation. Eight relations were identified as accounting for much of the manifest categories and were selected for use in the project. Additional relations were identified, screened for similarity to the eight previously selected, and added to the list. The following list of relations was adopted for use in the study, the first eight being from Whitely's study:

1. Class-Member (inclusion of one in the other)
2. Activity/Use (performing the same activity or having the same use)
3. Functional (performing some activity on or for the other)
4. Similarity/Equivalence
5. Conversion/Process (one is converted or processed from the other)
6. Order/Time (following one another in an order or in time)
7. Opposite
8. Cause-Effect
9. Pattern (having similar form patterns)
10. Association (being associated together)
11. Superior/Inferior (in power or authority)
12. Degree (more than or less than)

13. Part-Whole (as distinguished from Class-Member)

14. Worker/Tool-Product (specific association)

15. Position (spatial or ordinal relation)

In the course of the project, only the first 10 relations were used in the studies on verbal analogies and--with the exception of Relation 4 (Similarity/Equivalence) for which Relation 14 (Worker/Tool-Product) was substituted--in the studies on picture analogies as well.

Determination of Relation Eduction Index for Element Pairs

A quantitative index was needed to operationalize the variable, "level of difficulty of educing a given relation in a given element pair." The index chosen was the percentage of a group of subjects who indicate that a given relation is present in a given word pair or picture pair. This index was called the "relation eduction index" (REI).

The major data collection effort in this project was devoted to collecting REI norms. REI data were obtained for the first eight relations on the first 1,000 word pairs from an undetermined number of college students (Soriano, Dawis, & Siojo, 1974, Technical Report No. 4); for the first 10 relations on all 1,500 word pairs, from 3,486 high school students (Dawis, Haynes, Soriano & Siojo, 1974, Technical Report No. 5); and for 10 relations on the 500 picture pairs, from 3,311 high school students (Haynes, Dawis, Monson, Lopez, & Soriano, 1974, Technical Report No. 6). The college student sample was quite homogeneous in age, ability, education and, to a lesser extent, social class. The high school samples were more heterogeneous, and biographical data were obtained on grade in school, school, sex, age, race, number of children in family, reported annual income, housing, father's education, mother's education, father's occupation and mother's occupation. These data were utilized to study the effects of the demographic factors of sex, race, and social class on the REIs. (See: Dawis, Soriano, Siojo, & Haynes, 1974, Technical Report 3; Haynes, Dawis, &

Soriano, 1975, Technical Report No. 7).

Construction of Biased and Unbiased Verbal Analogies

With REI information, it is possible to construct verbal analogies to specification, i.e., specifying what is desired in both stimulus and response pairs (including both "correct" response and distracters). Type of dominant relation and REI level can be varied simultaneously. With information on the effects of demographic factors, e.g., social class, it is further possible to construct verbal analogies biased in favor of one group or another, i.e., with REI levels favoring one group or another.

Accordingly, to investigate the effects of social class on analogical reasoning, verbal analogies were constructed to be biased in favor of the higher social class, likewise the lower social class, and to be unbiased (favoring neither group). Utilizing the data given in Technical Reports 3 and 5, 12 items were constructed to be biased in favor of the higher social class ("biased-high"), nine items biased in favor of the lower social class ("biased-low") and 21 items that were unbiased. "Social class" in this item construction was defined by reported annual family income, with those reporting over $10,000 being classified as "high" social class, and those reporting "10,000 and below as "low" social class. Stimulus pair and "correct" response pair (same relation) were matched for REI level in the keyed relation. Distracter pairs were matched in REI level--but for the "wrong" (non-keyed) relation--with the stimulus pair. Distracter pairs had lower REIs on the keyed relation than the correct-response pair. The construction of biased items utilized word pairs appearing in Technical Report No. 3 for both stimulus and correct-response pairs (i.e., both stimulus and correct-response pairs were selected to have REIs on the keyed relation in favor of the group being favored).

Study of Biasing Effects of Social Class

Three samples were used in this study: 440 mostly white 12th grade students

in a Twin Cities area high school; 170 white 12th grade students from two Memphis area high schools, and 136 nonwhite 11th and 12th grade students from the same Memphis area high schools. The three groups of items--12 biased-high, 9 biased-low, and 21 unbiased--were administered to the subjects by their teachers in a single one-hour session.

For data analysis, the subjects were classified into "high" and "low" social class groups according to a weighted combination of reported annual family income, father's education and father's occupation. The upper 25% of the group was defined as "high" and the lowest 25% of the group was defined as "low" social class. Group differences were examined at the test (item group) level and at the item level.

Study of the Hierarchical Ordering of Relations

Using REI information, 2-choice items were constructed in which the stimulus pair had equivalent REIs for two keyed relations and the two response pairs had opposite patterns of REIs, high for one keyed relation and low for the other. Thus, choice of one response pair would indicate preference for, or the dominance of, one relation over the other. Sixty-eight items were constructed, representing 14 pairings of eight relations out of a possible 28 pairings. (Despite the large number of word pairs available, a complete paired-comparison matrix of pairings was not realizable.) The items were administered in a counterbalanced design to 71 college students. (See Technical Report No. 8, Monson & Dawis, 1975, for more details.)

Results

1. As the REI norms (Technical Reports 4, 5, and 6) show, different relations have different REIs for the same word pair or picture pair; and, different word pairs or picture pairs have different REIs for the same relation. (Despite the large number of subjects participating in the normative studies, the cell ~~means~~ N/S are relatively small, with the SE ranging from 4 to 11%; hence

the REIs may be somewhat unstable. However, extreme REIs, either high or low, can be utilized with confidence.) This basic finding of differential REIs was, of course, expected, but specific REI information was required before either of the project objectives could be pursued.

2. Also as expected, differences in REIs were observed for different sex, race, or social class groups. Table 1 summarizes the data given in detail in Technical Reports 3 and 7.

What was not expected was the small number of word and picture pairs showing demographic-group differences. At an alpha level of .05, 60 items in 1,200, 67 in 1,350, 20 in 400, and 25 in 500, would be expected to show group differences by chance, hence much of the results shown in Table 1 can be considered to be chance results. Neither sex nor social class appears to have had much effect on REIs. The absence of sex effects was expected but the absence of social class effects was not. In retrospect, perhaps by minimizing the influence of word knowledge (vocabulary level) through the restriction of words used to the first 5,000 or the 4th grade level, the influence of social class on the REIs was effectively eliminated or minimized.

The exception to the nonsignificant findings was the presence of some race effects. Table 1 shows that race (white vs. nonwhite) is a factor (where sex and social class may not be). Even at this low vocabulary level, the eduction of relations (cognition of relations) differs perceptibly for the two race groups. (One is tempted to extrapolate to the well-documented finding of race differences, favoring whites, on verbal analogy tests. The present finding of race effects bears further investigating.)

Surprisingly, too, more effects of sex, race and social class are seen in the picture pairs than in the word pairs. Again, this could be due to the low vocabulary level used for the word pairs, or alternatively, to the quality of the drawings used in the picture pairs.

Table 1

Number of Element Pairs with Significantly ($P \leq .05$)
Differing REIs for Sex, Race and Social Class Groups,
by Type of Element Pair and Type of Relation

Type of Relation	Word Pairs				Picture Pairs			
	N pairs	Sex	Race	Social Class	N pairs	Sex	Race	Social Class
1. Class-Member	1350	36	77	39	500	27	29	5
2. Activity/Use	1350	35	52	16	500	21	52	12
3. Functional	1200	21	52	13	400	22	15	9
4. Similarity/ Equivalence	1200	29	77	16	--[a]	--	--	--
5. Conversion/Process	1350	28	85	51	400	14	36	6
6. Order/Time	1350	30	32	12	500	13	22	0
7. Opposites	1200	20	29	15	400	16	38	4
8. Cause-Effect	1200	25	64	18	500	27	58	32
9. Pattern	1350	9	21	2	400	24	39	8
10. Association	1350	24	53	16	400	12	20	9
14. Worker/Tool-Product	--[a]	--	--	--	500	23	41	17

[a] Relation was not used.

A final, obvious, finding shown in Table 1 is that the effect (whatever there is) of sex, race and social class on relation eduction appears to be differential for the different relations.

3. The results of comparing the performance of high and low social class groups on specially constructed biased-high, biased-low and unbiased verbal analogies are summarized in Table 2.

Table 2 shows a significant difference in average performance between high and low social class groups on the biased-high and unbiased tests. In both cases, the difference in means is small and favors the high social class group. Since these groups were "extreme" groups (i.e., upper and lower 25%), the findings shown in Table 2 appear to support the previous observation that the effects of social class as a biasing factor are small, if any, on the kind of verbal analogies used in this study.

Analysis of variance using a two-factor, repeated measures design (with social class and items as the two factors, repeated measures on items) showed only one significant source of variation: the items. However, chi square analysis of item response distributions (response by social class group), undertaken separately for each item and for each sex-by-sample subgroup, yielded only six significant findings at the .05 level out of a total of 168 separate chi square tests conducted. Again, these analyses fail to find any clear effects of social class.

Three observations might be made about these results:

1. If the REI data are reliable, one would expect that the advantage in performance would lie with the favored groups on the biased tests (or items) and with neither group on the unbiased tests (or items). Considering the three-stage Spearman process of analogical reasoning (apprehension of elements, eduction of relations, eduction of correlates), the present study attempted to eliminate any advantage at the apprehension-of-elements stage, and to give the

Table 2

Performance of High and Low Social Class Groups on Biased-High, Biased-Low, and Unbiased Verbal Analogy Tests

	Test	Group	N	$\bar{X}$	SD	t
1.	Biased-High	High	127	5.92	1.79	1.98*
		Low	112	5.42	2.02	
2.	Biased-Low	High	127	5.33	1.73	1.37
		Low	112	5.02	1.79	
3.	Unbiased	High	127	12.38	3.13	2.18*
		Low	112	11.44	3.49	

*$P \leq .05$

advantage to the favored groups at the eduction-of-relations stage. If this "treatment" was successful, a finding of "no difference" in performance on the biased tests would lead one to suspect an offsetting advantage at the eduction-of-correlates stage. Such an offsetting advantage would obtain if, for example, it were true that the high social class group was superior to the low social class group in the ability to reason analogically. High social class superiority in analogical reasoning ability would account for the lack of a difference on the biased-low test and the significant difference favoring the high social class group on the unbiased test. However, it would not account for the barely perceptible difference on the biased-high test. On this test, the difference should have been much more pronounced. Furthermore, the item data do not support an hypothesis of high social class superiority in analogical reasoning ability.

2. The preceding analysis--again, assuming that the "treatment" in the study "took," resulting in no advantage at the element-apprehension stage and an advantage to the favored groups at the relation-eduction stage--would lead one to suspect that perhaps the critical ability in analogical reasoning (i.e., the essence of analogy) is the ability, in the Spearman formulation, to educe correlates, or more precisely for this study, the ability to see the same relation that binds the elements in both the stimulus pair and the response pair. Even an advantage in educing relations does not appear materially to help the favored groups. While the data in this study are consistent with this hypothesis (that the critical ability is educing correlates), the study was not designed to test it, and the hypothesis at this point remains speculative.

3. It also appears from the data in this study that the superiority of high social class groups on verbal analogy tests may, in large measure, be due to the advantage in word knowledge held by the high social class groups. When this advantage is nullified, as in this study, the superiority of the high social

class groups is very tenuous, and individual differences in analogical reasoning ability come to the fore.

Finally, the results of the study on the hierarchical ordering of relations (Monson & Dawis, 1975) provide evidence that in ambiguous situations certain relations are consistently preferred over others in the solution of verbal analogies. There appears to be clear preference for Cause-Effect, Opposite, Conversion/Process in that (descending) order, and clear preference against Order/Time, Functional, and Class-Member in that (ascending) order. This hierarchical ordering of preference for relations, however, is based on aggregated data, and there is ample avidence of individual differences in hierarchical order of preference.

Two implications of these (hierarchical ordering) findings might be pointed out:

1. Cultural group differences, e.g., sex, race, and social class differences, in analogy test performance may lie, in part, in cultural differences in the preferred hierarchical ordering of relations. Thus, the item writer may unwittingly favor his/her cultural group when constructing analogy items, resulting in a spurious finding of superiority for the favored group on tests of analogical reasoning.

2. The finding of a hierarchical ordering of preference for relations raises the question of its origins. One would expect to find answers in developmental studies similar to those conducted by Piaget on logical thinking. The interesting question would concern the relative contributions of maturation and culture to the development of such hierarchical ordering of preference for relations.

Conclusions

This project had two objectives: generally, to study the process of analogical reasoning, and specifically, to investigate the effects of social class

on this process. The results of this project lead to the following conclusions:

The Spearman formulation of analogical reasoning as a three-stage process (apprehension of elements, eduction of relations and eduction of correlates) appears to be useful in the study of analogical reasoning. In this project, minimizing the role of the first stage (element apprehension) and manipulating the second stage (relation eduction) resulted in the unexpected finding of minimal effects attributable to social class. Thus it might be concluded that the social class variable exerts its influence primarily at the first stage of the analogical reasoning process, i.e., in the apprehension of the elements. Little evidence was found in this project for social class effects in the total analogical reasoning process when social class effects in the apprehension of elements were minimized.

The findings in this project also lead to the hypothesis that the most important stage in the analogical reasoning process is probably the third stage, the eduction of correlates. It appears that an advantage at the second (eduction of relations) stage is not compelling and can be overridden at the third stage. In any event, if cultural advantage is eliminated or minimized at the first (apprehension of elements) stage, culture (specifically, in this study, social class) appears to exert only minimal influence on verbal-analogy-test performance.

The finding of a hierarchical ordering of relations preferred (i.e., utilized) in analogy problem solving adds to the explanation of the well-documented social class differences in analogy test performance. In addition to (and probably combined with) the influence of the word-knowledge (vocabulary level) factor--which appears to be the primary factor--the relation preferences of the analogy test constructor may artifactually help give the advantage to the test constructor's cultural group.

Thus, the effects of social class on the analogical reasoning process

are contingent on the elements and possibly on the relations chosen for use in analogy tests.

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